TABLE OF CONTENT

1.	Introduction	1
2.	The Workshop	3
2.1.	Programme	3
2.2.	Opening Session	4
2.3.	Closing Day	6
3.	Evaluation and Recommendations	8
ANNEX I	List of Participants from Developing Countries	11
ANNEX II	1. Workshop Programme	14
	2. Name and Function of Lecturers	19
	3. Brief introduction to OMV	
ANNEX III	Summary of Lectures	20

1. Introduction

Energy consumption in developing countries is dominated by petroleum in both petroleum exporting and petroleum importing countries. The rising price of oil over the last decade has created very obvious difficulties for developing countries to meet their energy requirements in line with the overall growth rate of their economies.

The acquisition and management of technology and skills is therefore a fundamental issue of petroleum enterprises in developing countries for the operation of their refineries at maximum efficiency.

In view of the wide disparity of technical, managerial and administrative experience among petroleum enterprises and given the need for technology transfer and training experience by developing countries, the United Nations Symposium on State Petroleum Enterprises, held in Vienna, Austria, March 1978, stressed the importance of the establishment of closer links among petroleum enterprises. It was pointed out that national petroleum refineries in developing countries will doubtlessly not be less successful than multinational petroleum companies if their technical personnel were provided more frequent opportunities, possibly on a continuous basis, to exchange experience and information among themselves on the problems and constraints of their refineries, and keep themselves abreast of the latest developments in petroleum refining.

In line with these recommendations, UNIDO in close co-operation with the OPEC Fund, the national Petroleum company of Austria, OMV, and the Austrian Federal Economic Chamber organized its first workshop in the field of petroleum refining "Workshop on Petroleum Processing", held in Vienna from 21 to 30 April 1981. The workshop was intended particularly for those developed countries (LDCs) whose state-owned or state-controlled petroleum refineries are in urgent need of assistance to improve their efficiency and competitiveness.

This workshop programme included the following subjects:

- refinery personnel organization
- personnel training
- refinery operation
- utilities
- maintenance
- environmental control and energy conservation
- trouble shooting.

These subjects were discussed with a view to providing assistance to refinery engineers mainly at a managerial level. Although the objectives of the workshop were largely achieved, it was felt that future workshops should be arranged annually, if possible.

This, combined with the need for more in-depth discussion on selected subjects led to the arrangement of a second workshop held from 3 to 19 May 1982, the programme of which focussed only on three topics:

- trends in petroleum processing
- production planning
- energy management.

As participants and sponsors of the preceding two workshops repeatedly pointed at the lack of sufficient experience in maintenance and plant inspection in petroleum refineries of developing countries, a workshop on these topics was organized, which took place in Vienna, Austria, from 5 to 23 September 1983.

The technical programme of the two preceding workshops as well as of this workshop, was conducted by OMV, Austria, in their refinery at Schwechat, and included lectures, discussions and plant visits.

For over two decades Austria has owned and operated a successful petroleum enterprise, covering the whole range of oil and natural gas industry, from exploration and production to refining and distribution. OMV has erected a modern, efficient refinery at Schwechat to replace the many small, inadequate refineries that existed before 1955 at

the oil fields situated in Eastern Austria. The Schwechat refinery is reported to be the largest Central European refinery with a yearly throughput capacity of 14 million tons. The presence of multinational corporations has forced OMV to always apply the most modern processing methods, the latest technical knowledge. It is believed that the experience gained by OMV could provide useful guidelines for developing countries.

2. The Workshop

The organizers selected jointly 57 developing countries to be invited, among them 25 countries, including OPEC member countries, to attend the workshop entirely at their own costs. Candidates from the remaining 32 countries were requested to share 50% of their individual air travel cost, while daily subsistance allowance and tuition fees were borne by UNIDO. Invitation letters together with the workshop programme and aide-mémoire were sent to each Government through the UNDP office in the country. Selection of candidates was carried out jointly by the organizers based on the candidate's background and on information about his refinery, which the candidate was requested to provide by filling in a questionnaire.

While the participants of the 1981 workshop were mainly refinery directors and managers and of the 1982 workshop engineers and superintendents, the 1983 workshop was designed for refinery personnel specialized in maintenance and inspection, such as maintenance engineers, heads of workshops and plant inspection engineers.

Twenty-two suitable participants were selected for the workshop, ... 12 of them attending the workshop at their own cost (Annex I, list of participants).

2.1 Programme

As for the two preceding workshops, the technical programme ..... of this workshop (see Annex II), consisting of lectures, discussions, plant visits and visits to Austrian companies, was arranged by OMV, and conducted at their Schwechat refinery. OMV assigned about

12 engineers, many of them for the entire duration of the workshop, to prepare background papers and assist in the lectures and discussions. Lecture outlines, technical specific data and drawings were distributed to the participants each day. The lectures of the workshop programme ..... are summarized in Annex III.

The workshop was opened with a session at UNIDO, followed by a moderating session at OMV, where participants and OMV staff assessed further specific problems, which the participants would like to have included in the workshop programme. The closing session was intended for discussions on the workshop results and follow-up activities and recommendations on future co-operative programmes.

2.2 Opening Session

Mr. D.G.A. Butaev, Director, Division of Industrial Operations, UNIDO, pointed out in his opening speech the important role played by petroleum refineries in the economies of developing countries and the need for concrete proposals for raising their efficiency and competitiveness. He went on saying that exchange of experience and information and the establishment of closer working relationships among refinery personnel were useful elements for the achievement of that objective. As the response to invitations of this year's workshop was particular good, Mr. Butaev said that the subject of this workshop together with high quality of lectures, presentation and discussion arranged by the staff of OMV must be responsible for the enthusiasm shown by the developing countries in this year's workshop.

The next speaker was Mr. F. Schmid, Alternate Permanent Representative of Austria to the United Nations in Vienna, who emphasized the importance his Government attaches to the co-operation with UNIDO in the implementation of practical work supporting the promotion of industrial development in developing countries. Experience exchange, as a form of training, he said, was of paramount importance. He expressed the hope that in the field of petroleum refining, Austria, through its national petroleum company OMV, would successfully assist in the improvement of maintenance and plant inspection of refineries in developing countries.

The floor was then given to Mr. Awni Al-Ani, Assistant Director General, OPEC Fund for International Development, who referred in his speech to the experience the OPEC Fund had gained in its own projects in developing countries and the effect that the lack of maintenance had on the outcome of these projects. He also stated that workshops of this kind were important in view of the high operation costs of refineries in developing countries due to bad maintenance and in view of the need for improvement in that field. He was confident that expertise offered by OMV would be very useful and beneficial for the workshop participants.

OMV was represented at the opening session by Mr. Herbert Kaes, Director General, who drew the attention to the 1978 UNDTCD Symposium on State Petroleum Enterprises, Vienna, when the idea for this series of refinery workshops was proposed by the then OMV Director General, Mr. Ludwig Bauer. Mr. Kaes expressed the feeling that the importance of maintenance and plant inspection for petroleum refineries was too often underestimated. He added that this issue was equally important for petroleum refineries of industrialized countries as indicated by the results of the latest World Energy Conference (1983).

The opening session concluded with the speech given by Mr. Heinrich Lederleitner from the Austrian Federal Economic Chamber, an organization which supports through the Austrian Government several programmes implemented by UNIDO, especially in the field of petroleum industries

as explained by Mr. Lederleitner. He then gave a brief outline on the objectives and the structure of his organization. The Austrian Federal Economic Chamber is the top organization representing through its 80 trade delegations in foreign countries, Austrian industries, trading companies, tourism, transport and banks. The organization is equally involved in the export from Austria as in the import to Austria. He mentioned that with his organization's support, the UNIDO Investment Promotion Service for Austria for the intensification and generation of industrial investment projects had been recently established.

2.3 Closing Day

The morning of the closing day was devoted to a visit to the OPEC Fund for International Development in Vienna, where the participants were introduced by Mr. Benamara, Director of Information, to the organization and work of the OPEC Fund. He explained that the OPEC Fund receives voluntary contributions from its 13 member countries, which form the financial basis for the Fund's technical co-operation and lending programmes in developing countries. Mr. Benamara added that about 50% of the loans and grants of the Fund's projects were in the field of energy, mainly for least developed and food deficient developing countries.

During the subsequent discussion several questions were raised concerning loan and grant application and administration. The OPEC Fund replied that technically and financially sound project proposals were the main elements for the decision making process on which selection of countries applying for assistance from the OPEC Fund were based.

During the closing ceremony, Mr. H. May, Deputy Director of the Division of Industrial Operations, UNIDO, thanked all co-organizers and participants for their efforts towards the success of the workshop. He pointed at two major problems: How to promote and maintain a continuous exchange of information among the petroleum refineries in developing countries themselves and with OMV and, secondly,

how to improve the efficiency of refineries in the developing countries and help solve them the many problems that they are facing. Furthermore he stressed the need for co-operation among the various national and international organizations in pooling their resources for the implementation of programmes recommended during the workshop.

Mr. Harald Miltner, Advisor to the Permanent Representative of Austria to UNIDO commented in his speech on the usefulness of such workshops, while Ms. Najib on behalf of the OPEC Fund for International Development complimented the participants and organizers on the success of the workshop.

In his closing address, Mr. Herbert Kaes, Director General of OMV, mentioned the mutual interest and benefit this type of workshop offered to the participants as well as to the organizers. He emphasized the importance of environmental issues for petroleum industries. He added that Austria's environmental policy has forced legislation to enter into the preparation of laws related to air and water pollution standards and control, which will become effective in the near future, and place Austria among the leading countries in this field.

The Austrian Federal Economic Chamber was represented by Mr. Karl Haas who said that his organization gladly contributed to this workshop not only financially but also through providing contacts with manufacturers of machinery and equipment for petroleum refineries. He referred to the mutual usefulness of such contacts.

Mr. Tadikonda Virabhadra Prasad, India, spoke in the name of all workshop participants expressing appreciation to the organizers and the sponsors of the workshop for their efforts made towards the success of this workshop. He stressed the importance of the workshop topic for developing countries and commented on the high quality of the technical programme as presented by OMV.

Preceding the closing ceremony, a round table discussion with the participants, the organizers and some of the lecturers was organized, to evaluate the workshop programme and to establish recommendations for future co-operation in this field. The workshop conclusions and recommendations are described in the following chapter.

3. Evaluation and Recommendations

This year's workshop was the third in a series of workshops dealing with the various aspects of petroleum refinery industry organized by UNIDO. The topic Maintenance and Plant Inspection must have been one of the reasons for the good response to the invitations to the workshop. From the 22 selected workshop participants, 12 participants came at their Government/organization's cost. The other 10 participants who attended the workshop at UNIDO project cost had to contribute 50% of their air travel fares.

It was generally agreed that the objectives of the workshop had been largely achieved and that this year's technical programme was of great benefit to the maintenance and inspection engineers from developing countries.

It was felt by the participants and the staff members of the sponsoring organizations, who were closely involved in the preparation and conduct of the workshop, that the results of the workshop were a valuable contribution towards furthering the exchange of practical experience and know-how in petroleum refining.

During the preceding two workshops and also during this workshop, participants emphasized the importance of arranging similar workshops annually, if possible. This type of technical consultation plays a significant role for refinery managers and engineers from developing countries to promote co-operation among themselves and/or consult specialist staff on specific problems.

The need for establishing an experience exchange group on the problems of petroleum refineries in developing countries was stressed by a number of workshop participants. This was supported by the sponsoring organizations, as such experience exchange groups exist in industrialized countries and have proved to be of considerable benefit for the participating petroleum refineries. Staff from OMV, Austria, mentioned that prior to the meeting of such an experience exchange group, a problem catalogue is presented to its committee, which then prepares proposals for solution for discussion at the meeting. The participants from India, Venezuela and Nigeria mentioned that on a national and sometimes also on a regional level their refineries had already taken steps towards setting up such experience exchange groups. But all participants agreed that UNIDO should follow up this idea, define the terms of reference for such an experience exchange group and mobilize resources for its materialization. It was recommended that at the beginning the experience exchange group should concentrate on issues related to maintenance and plant inspection, but later broaden its scope of activities to other topics of petroleum refining such as

- process performance data,
- energy conservation schemes,
- environmental control,
- inspection of equipment and corrosion problems,
- rotational equipment failure analysis and predictive maintenance,
- training methodologies and programmes for operators/inspectors/maintenance personnel,
- safety aspects,
- application of computerized process control.

The question arose whether maintenance and plant inspection should be separately dealt with at different workshops. Most of the participants agreed that these two topics are interrelated and should therefore not be separated.

There was a short discussion on more company/plant visits and practical demonstration work during the workshop programme. It was however pointed out that this would be a little outside the scope of the programme.

Some participants invited UNIDO to compile a list of suppliers for commonly used parts. It was indicated by UNIDO that in view of existing trade directories and catalogues, such compilation appeared not very meaningful.

In addition, the request for more specialization in the programme, e.g., corrosion and inspection, was briefly discussed. It was pointed out that it was difficult for the organizers to design a programme which meets the exact expectations of each participant. There was general agreement that very special problems were dealt with better by an experience exchange group.

UNIDO's technical assistance programme in the energy sector and the framework under which such assistance can be obtained were introduced to the participants during the workshop. Certain requirements were expressed in the field of training, mainly for very specialized courses, in addition to experts services and equipment supply.

ANNEX I

List of Participants from Developing Countries

Country	Name and address of participant
Algeria	Mr. Oulmi Mohamed SALAH Engineer Sonatrach
Angola	Mr. Adao Mauricio KIALA Ambrosio Inspector of Installations Petrangol Refinery Rua Rev. Agostinho Pedro Nr. 20-2-A APT 22 Luanda, TELEX: 3329 PETMAT/AN 3033 PETREF/AN
Burma	Mr. Myint Oo Maintenance Engineer Petrochemical Industries Corp. 33, York Road Rangoon, TELEX: 21329 BM PECHEM
China	Mr. Xiaolei ZHANG Engineer/Maintenance Management China Petroleum Processing Corp. Liu Pu Kang Beijing, TELEX: 22312 PCPRC
Ethiopia	Mr. Yigzaw MEKONNEN Engineer Head Ethiopian Petroleum Corp. Addis Ababa, TELEX: 21054
Ghana	Mr. Frank Godfrey ESSIAW Assistant Technical Manager Ghaip Oil Refinery P.O. Box 599 Tema
India	Mr. Tadikonda Virabhadra PRASAD Specialist Manager Engineers India Ltd. 4, Parliament Street New Delhi 110001, TELEX: 031-3827
Ivory Coast	Mr. Honoré KHISSY BEYNIOUAH Assistant to Chief of Technical Department Société Multinationale de Bitumes (S.M.B.) 12 BP 622 Abidjan, TELEX: 42 539
Libya	Mr. Bashir Mohammed NAJJAR Inspection Division Head Azzawiya Oil Refining Co. P.O. Box 645 Tripoli, TELEX: 30423

List of Participants from Developing Countries (Cont...)

Country	Name and address of participant
Nigeria	Mr. J.A. AKANDE Mr. P. EGHO National Petroleum Corp.
Oman	Mr. Redha Hassan ABDUL-RASOOL Assistant Maintenance Engineer Oman Refinery Company LLC P.O. Box 6568 Ruwi, TELEX: 3123 ORC MCT
Philippines	Mr. Ruben Fulgencio DE LEON Assistant Maintenance Manager Mr. Juan Wilfrido C. BONOT Planning Engineer Bataan Refining Corp. 7901 Makati Ave., Makati MM Metro Manila TELEX: PNOPH 633667 PNOC PN
Sri Lanka	Mr. Don Patrick Eugene Nimal RAJAPAKSA Manager, Mechanical Maintenance Ceylon Petroleum Corp. Refinery P.O. Box 11 Kelaniya, TELEX: 21167 CEPETCO CE
Tanzania	Mr. Lot M.A. CHIHOMA Technical Planning Officer Tiper Co. Ltd. Kigamboni Refinery Site Dar-es-Salaam, TELEX: 41005
United Arab Emirates	Mr. Abdullah Mohammad AL JENAIBI Jr. Mechanical Engineer Abu Dhabi National Oil Company Khalifa Street, Adnic Building Abu Dhabi, TELEX: 24232 ADNOTP EM
Uruguay	Mr. Walter DURA REY Mechanic Industrial Engineer A.N.C.A.P. Luis de la Peña 1000 Montevideo, TELEX: UY 6692
Yemen, P.D.R.	Mr. Mohammed HAMEED ABDO Plant Inspection Engineer Mr. Mohsen Ali SAEED Planning, Programming and Records Engineer Aden Refinery Company P.O. Box 3003 Aden TELEX: 2213 ADRFINRY

List of Participants from Developing Countries (Cont....)

Country	Name and address of participant
Venezuela	Mr. Alberto BEUSES Amuay Refinery Deputy Manager Lagoven, S.A. (Petróleos de Venezuela) 527 Tachira Judibana - Falcón TELEX: 54169
Zambia	Mr. Hubert Mubanga BWALYA Chief Engineer Indeni Petroleum Refinery Co. Ltd. Bwana - Mkubwa Ndola, TELEX: ZA 34221

ANNEX II

1. Workshop Programme

5 September 1983

9:00 OPENING SESSION AT UNIDO

Chairman pro tem: Mr. M. Maung, Industrial Development Officer, Chemical Industries Branch Division of Industrial Operations, UNIDO

Opening Speech: Mr. D.G.A. Butaev, Director, Division of Industrial Operations, UNIDO

Speeches by: Dr. Franz Schmid, Alternate Permanent Representative of Austria to UNIDO

Dr. Awni Al-Ani, Assitant Director-General The OPEC Fund for International Development

Dr. Herbert Kaes, General Director ÖMV Aktiengesellschaft

Dr. Heinrich Lederleitner, Director Austrian Federal Economic Chamber

11:00 ARRIVAL AT ÖMV REFINERY SCHWECHAT

- Welcome by the Refinery Manager — Cech
- Introduction of all associates participating in Workshop — Cech
- Presentation of the Workhop Programme
- Brief introduction to ÖMV AG — Smejda

14:30 VISIT THROUGH THE REFINERY

6 September 1983

9:00 MAINTENANCE	Lecturer/Moderator
- General Overview/Introduction	Maier/Miglitsch
- The Total Maintenance Function	Maier/Miglitsch

12:00 LUNCH in the Refinery

		Lecturer/Moderator
13:00	- Shutdown planning and scheduling (network technique)	Maier/Miglitsch
	- Maintenance internally or externally (by contractor)	Maier/Miglitsch

7 September 1983

9:00	- Maintenance of equipment, compressors, turbines	Miglitsch/Kloyber
12:00	LUNCH in the Refinery	
13:00	- Maintenance of process pumps	Sieh/Miglitsch
	- Maintenance of instrumentation (pneumatic, analysis equipment)	Kloyber/Miglitsch

8 September 1983

9:00 MAINTENANCE

- Maintenance of instrumentation (process analysis equipment) — Kloyber/Brantner

MATERIAL SUPPLY

- Flow of information concerning spare parts — Kreisler/Brantner
- Spare parts ordering inside refinery and from outside suppliers — Kreisler/Brantner

12:00 LUNCH in the Refinery

13:00 MATERIAL MANAGEMENT

- Warehouse management
- Material handling — Brantner/Kreisler
- Material administration

Visit to OMV refinery warehouse.

9 September 1983

Reception at the Federal Economic Chamber of Austria and meetings with various companies and manufacturers of refinery-related equipment.

Visit to OMV's central workshop and warehouse.

10 and 11 September 1983 (Saturday/Sunday)

12 September 1983

9:00	- Corrosion problems in petroleum refineries - Scheduling equipment for inspection - Inspection methods - Deterioration and failure of equipment and its prevention - Question/Answer-Session on the above topics	Hornasek
12:00	LUNCH	
13:00	- Corrosion protection by organic layers (Paint). On-site demonstration in co-operation with the FERROPAN-Bautensch. Comp. - Lifetime of equipment - Detailed equipment inspection - On-stream inspection and special testing methods Part 1: Ultrasonics	Hornasek

13 September 1983

9:00	- On-stream inspection and special testing methods Part 2: Thermovision, acoustic emission - Practical demonstration of selected NDT techniques - Special Schwechat Refinery problems and their solutions - Filing and documentation - Visit to the ACOUSTIC EMISSION TRAILER with on-site demonstration in co-operation with TÜV-Vienna	Hornasek
12:30	LUNCH	
13:30	- Material standards - Pressure parts - High/low temperature service - Austrian pressure vessel code - NDT/DT testing regulations for materials - Question/Answer-Session on the above topics	Wischin (TÜV)

14 September 1983

	Visit to VOEST ALPINE steel mill	Smejda

15 September 1983

9:00	TROUBLE SHOOTING	
	- General considerations about equipment failures	Maier/Miglitsch
	- Turbo machines and pumps (Bentley system, predictive maintenance)	Miglitsch/Maier
12:00	LUNCH	
13:00	Field trip through selected units within the refinery.	

16 September 1983

9:00	MAINTENANCE ORGANIZATION and MAINTENANCE INFORMATION SYSTEM	Maier/Sieh
12:00	LUNCH	

17 and 18 September 1983 (Saturday/Sunday)

19 September 1983

	Material Economics and Computer Systems	Strauss/Klima

20 September 1983

9:00	Special problems raised by participants during moderating session	
12:00	LUNCH	
14:00	Afternoon at UNIDO	

21 September 1983

9:00	ATS (Analytical Trouble Shooting)	Huber
12:00	LUNCH	
13:00	ATS	Huber
15:30	Visit to SIMMERING-GRAZ-PAUKER	

22 September 1983

9:00	Training Maintenance Personnel	Schweng
	Planning of repair shops	Kielhauser
12:00	LUNCH	
13:00	Discussions of problems related to FCC	Weithofer
14:00	Summary and conclusion	

23 September 1983

10:00 Visit to OPEC Fund for International Development

12:30 LUNCH offered by OPEC Fund

14:00 Closing Session at UNIDO

Opening remarks for discussion on Workshop results and follow-up activities by Mr. M. Maung (Chairman)

- Participants' views on the programme
- Comments by the organizers
- Recommendations on future technical co-operation and follow-up activities.

15:30 Closing Ceremony at UNIDO

Chairman pro tem: Mr. M. Maung, Industrial Dev. Officer, Chemical Industries Branch Division of Industrial Operations, UNIDO

Closing speech by: Mr. H. May, Deputy Director, Division of Industrial Operations. UNIDO

Statements by: Mr. Harald Miltner, Counsellor Adviser to the Permanent Representative of Austria to UNIDO

Dr. Herbert Kaes
General Director
OMV Aktiengesellschaft

Mr. Karl Haas
Austrian Federal Economic Chamber

Dr. Tadikonda Virabhadra Prasad, India
Speaker for Workshop Participants

Award of Certificates

16:00 Reception at UNIDO

ANNEX II

2. Name and Function of Lecturers

a) Scientist

Prof. Dipl. Ing. Dr. Fritz PASS	Head: OMV Central Research and Development Department; Professor at Technical University, Vienna

b) OMV Headquarter Staff

Dkfm. Heimo HUBER	Head: OMV Training Department
Dipl. Ing. Peter KIELHAUSER	Assistant to Chairman of the Executive Board
Mag. Viktor KLIMA	Head: Concern Organization

c) Refinery Experts

Dir. Dr. Franz CECH	Refinery Manager
Ing. Josef MAIER	Head: Refinery Maintenance Department
Mag. G. BRANTNER	Deputy Commercial Manager
Ing. A. HORNASEK	Head: Refinery Inspection Department
Dipl. Ing. Dr. H. KLOYBER	Head: Instrument Department
Dipl. Ing. H. KREISLER	Asst. Technical Manager
Dipl. Ing. MIGLITSCH	Asst. Maintenance Manager
Dr. J. SCHWENG	Refinery Training Department
Dipl. Ing. H. SIEH	Maintenance Department

d) Affiliates/Consultants

Dipl. Ing. RAABER	TUV (Technischer Überwachungsverein) Technical Inspection and Control Authority

e) Organization

Mrs. L. SMEJDA	OMV Training Department, Foreign Trainees Section

ANNEX III

Abstracts of Le[illegible]es

1. Maintenance in Refineries - An Overview (J. Maier)

The rationalization measures taken in recent years within the processing industries have led to the construction of an increased number of units/plants in the production sector, resulting in a decrease of the production costs. At the same time, however, the cost of maintenance - a labour-intensive sector - has considerably increased. Therefore efforts are being directed towards minimizing the costs of maintenance to the lowest economically and technically acceptable level. This implies careful design of maintenance strategies and their implementation.

The management of a refinery has therefore to plan and establish appropriate maintenance policies. Modern maintenance requires interaction between many different working groups of a refinery and cannot be left with the maintenance department alone, which, together with the staff of the production plants, will carry out the required maintenance function as defined in an overall refinery maintenance policy.

2. Maintenance Functions, Policy and Strategies (J. Maier)

Maintenance as a whole comprises all personnel and activities involved in the maintenance of a refinery. Maintenance policy is geared towards minimizing maintenance costs and generally would allow expenditures only in cases where the output contributes to the safety of personnel and plant equipment, to the refinery profitability and to the implementation of Government, community or labour organizations regulations. As a general principle the following guidelines may be observed: refinery-wide awareness and responsibility for maintenance expenditures; reasonable approach in terms of safety, profitability, environmental control, energy conservation; improvement of the skills of maintenance and other staff.

The day-to-day maintenance decisions may be guided by the following considerations:

- Break-down maintenance: A given system breaks down due to a part which has become completely useless and therefore needs either repair or replacement. The latter requires spare parts stockage causing storage costs.

- Preventive maintenance: Based on the estimated lifetime of parts, a scheme for planned exchange of parts can be developed. With larger plant systems this requires special index card systems for control and, from a certain size of the refinery on, the assistance of a computerized part control, exchange and supply system.

- Predictive maintenance: Since today various test methods are available to check the status of plant parts on stream, failure of equipment can be predicted within a certain uncertainty range and repair programmes, production and procurement schedules can be set up accordingly. These measures are

based on comparative analysis of cost of repair of defective part and production loss weighted against the consequences caused by total break-down envisaged for the defective part. Scientific methods combined with empirial data and practical experience will assist maintenance managers in the decision-making process.

- Corrective maintenance: In cases of high frequency of damages which may reveal a defect in the construction, a solution for the improvement of such a construction must be found.

3. Maintenance through External Contractors (J.Maier)

Many refineries have maintenance work done through outside contractors. The extent to which external contractors are assigned for this work depends largely on local conditions, the maintenance policy of the refinery and technical security regulations. The decision for an engagement of an outside contractor is usually guided by the following considerations: provision of know-how not available within the refinery; repair/overhaul of plants; periodic requests for maintenance works to be contracted and establishment of a contract on a permanent basis; high work peak loads within the refinery and lack of own personnel; requirement of very special technical devices and skills for certain maintenance works. Maintenance management must decide at an early stage whether work should be done through contractors or whether additional investment and recruitment of personnel is more appropriate for satisfying maintenance needs.

4. Shut-down Planning and Scheduling (J. Maier)

Very special methods are necessary for shut-down operations of a plant, which must be carried out at the shortest time possible. This is efficaciously done through network planning and network analysis (critical path planning method). This implies the preparation of a detailed work programme involving the plant manager, field technician, plant technician, the inspection department and the stop planner. Network plans are established and analyzed. Personnel is usually recruited through contracting firms. The shut-down programme is supervised and monitored preferably by the stop planner. A very important phase is the evaluation of data after work has been completed. These data represent a good basis for future planning.

5. Maintenance of Equipment - Compressors, Turbines (H. Miglitsch)

Plant equipment such as turbines and compressors need special attention in maintenance and service, whereby one has to distinguish between reciprocating compressors and turbine compressors and turbines. Organization of the responsibility for staff concerned with service and maintenance depends on the size of the refinery. Engineers and workers have to be trained almost on a continuous basis. OMV has made the experience that for turbines and compressors periodic service is not necessary but recommends regular protocols for controls of machine performance data. Through the variation of these data malfunctions can be identified. Reciprocating compressors, however, will require maintenance work at regular intervals as recommended by the manufacturer, mainly due to the higher wear rate of many parts of this type of compressor system. Several examples for maintenance work during a planned plant shut-down are given.

The degree of vibration of rotary machinery is a very strong indicator for imperfect alignment, instable bearings, unbalanced rotors, etc. These causes for malfunctions must be destroyed. Therefore the many different types of bearings must be checked as well as the rotors (pumps, fans, electric motor rotors, compressors, turbines), and the influence of the settling of the foundation and of temperature difference.

Some special instruments exist such as alignment calculator, bolt extensiometer, pressure test/repair facilities for compressor valves. Particularly the extensiometer appears to be very useful as it is a means to determine the precise length of a bolt (ultrasonic) and therefore provides the basis for accurate calculation of the bolt preload. It also can be used for checking relaxation and helps to prevent thermal cycling, vibration, gasket creep, load cycles and joint failures.

6. Maintenance of Process Pumps (H. Sieh)

An important cost factor represents the maintenance of process pumps. Pumps repair costs are approximately 7% of the total maintenance expenditures of a refinery. Most of the pump failures originate from defects in the mechanical seals (70%), bearings and oil seals, corrosion, erosion, cavitation, etc. OMV has developed a number of proceedings to reduce these cost factors.

7. Maintenance of Instrumentation - Pneumatic, Electronic Instruments (H. Kloyber)

For the control of approximately 6000 process variables, 3200 alarms and others, OMV refinery attaches importance to proper functioning of the respective control instruments. The types of instruments used - pneumatic, analog and digital electronic, microprocessor-based electronic - are all maintained by specially skilled technicians. Work is scheduled and organized for shut-down periods and for operation periods. There exists an experience exchange group on instrumentation which meets annually for two days presenting a catalogue of questions/problems for discussions.

8. Maintenance of Process Analysis Instruments (H. Kloyber)

Due to the relatively large number of analyzers (625) to be controlled, the process analyzer department of OMV has been divided into four groups: pH group (conductivity, pH, oil in water); O_2 group (O_2, viscosity, CO, CO_2, CPA, sulfur, pour point, IR, H_2S, boiling point, opacity); gas detection group (hydrocarbons, H_2S, portable gas detectors); process chromatograph group (GC, moisture analyzer). These instruments must be controlled exactly according to their maintenance manuals. Calibration of these instruments is an important task and must follow standardized sampling and analysis methods.

9. Material Supply - Spare Parts Information Flow and Purchase (H. Kreisler)

Being a relatively large refinery and involved in exploration, pipeline transport, engineering and construction, OMV has decided on a centralized purchase department. The material catalogue comprises 60,000 items. The material administrator revises this catalogue and the warehouse stocks according to actual requirements from the refinery. A selective control

system has been developed which takes into account spare parts needed with higher frequency than others. Most of the materials are ordered from Austrian companies, USA and European companies with an average delivery time of 10 weeks, whereby four weeks are needed to comply with administrative regulations within the organization.

10. Material Management (G. Brantner, V. Klima)

Material management comprises the management of the warehouse, material handling and administration. An efficient material management can greatly reduce the shut-down time of a plant. Therefore security for material supply has high priority.

At OMV, 50% of the stored spare parts are permanently on stock, also for cases of unforeseen events. This long range planning requires capital cost. Efforts are therefore directed towards reducing these costs through improving warehouse administration. Storage of materials classified into material groups helps to locate material (sequential system) easily but requires a considerable amount of space. A new storage system was developed following the findings that 80% of stored parts are smaller than 950 x 200 x 350 mm. A computer-aided storage information system was created for locating parts. The new storage system needs only half the space of the old one. In addition, a computer programme is being developed to support material administration taking into account catalogue and technical information, purchasing, warehousing and accounting.

11. Plant Inspection in Petroleum Refineries (O.P. Hornasek)

Plant inspection in general addresses the following issues: corrosion, lifetime of equipment and scheduling of inspection, inspection methods, deterioration/failure of equipment and its prevention, detailed equipment inspection, on-stream inspection and special test methods.

Corrosion problems: In oil refineries mild steel is the material most commonly used and it suffers from corrosion at various degrees caused by a variety of sources. It is necessary to determine the nature and mechanism of corrosion so that suitable and economical methods may be applied for its prevention. Various remedial actions are discussed such as coating/linings, addition of inhibitors, cathodic protection, and some causes for corrosion such as chloride stress corrosion cracking, polythionic acid stress corrosion cracking, sulfide stress cracking, uniform corrosion, acid corrosion, caustic corrosion, high temperature corrosion, are described.

Schedules for equipment inspection: Government regulation (e.g. Austrian pressure vessel law) determines the frequency required for inspection, in general not less than every three years, and for hydrotesting every six years. Only under very special circumstances can this schedule be modified, if Government authorities agree. Inspection work to be carried out is listed and recorded at the beginning of the calendar year by the inspection department, covering the work for vessels, piping, safety valves and leaking glands. Examples for inspection schedules are demonstrated.

Inspection methods: This part describes the methods to be applied for the preparation and execution of inspection work. The following points have to be borne in mind: local Government regulations, construction code requirements, inspection service for corrosive and non-corrosive equipment. General inspection may be carried out through visual inspection, hammer testing, gagings, followed by very special inspection methods as required. To determine the remaining lifetime of a given piece of equipment requires considerable experience. The decision on whether or whether not to withdraw equipment from service may be guided by two considerations: (i) the minimal allowable wall thickness, and (ii) lack of justification for economically acceptable repair.

Cleaning for inspection: Various methods exist for this purpose ranging from water/steam washing, manual cleaning, sand blasting, brushing, reaming, chipping, to chemical and thermal methods.

Metal loss measurements and calculations: The parameters which govern the lifetime of equipment are: minimum allowable thickness, remaining corrosion allowance, corrosion rate, remaining life. An example for estimation of actual lifetime is presented. The various methods for corrosion rate measurements are described and their application explained.

In addition, the means for pressure testing are presented and procedures and safety considerations are explained. A very important work within inspection is welding, which requires very skilled personnel. Different types of welding necessary for inspection in petroleum refineries are listed and briefly described.

Deterioration/failure of equipment: The major cause for equipment failure is due to mechanical failure and corrosive attack. A review is presented on effects on various material and equipment, caused by mechanical stress and corrosion and oxidation. In addition, material exposed to a very special environment, such as high sub-critical temperature, overheating and others, may change its surface characteristics which may lead to dangerous conditions. Furthermore, the basic principles of cathodic protection are described and the different applications are outlined.

Lifetime of equipment: Very careful thought must be given to the judgement of lifetime to be expected for equipment. Premature retirement of equipment can waste money, while overdue utilization may cause failure with fatal consequences. Establishing the lifetime to be expected for a platforming heater is presented in detail as an example. Furthermore, an example for calculating remaining lifetime based on original and actual wall thickness is carried out (determination of remaining corrosion allowance and remaining life).

Detailed equipment inspection: Guidelines to be observed when a full inspection for any piece of equipment is called for, are laid down. Importance is attached to safety precaution and to the general safe limits of equipment. This is followed by a detailed description of a complete inspection, including nomenclature, design and retirement criteria, construction materials and repair and testing of the following equipment pieces: columns, pressure vessels, storage tanks, heat exchanger and cooling towers, process furnaces and boilers, pumps, turbines, compressors and machinery, instruments, piping and fittings, joints, bulk transmission lines, structures, fire proofing, insulations and foundations, and services.

On-stream inspection and special testing methods: The inspection of equipment in operation requires non-destructive testing methods (NDT-methods). However, many details cannot be detected while the unit is on-stream. The types and basic requirements of methods for on-stream inspection are described, which include visual inspection, ultrasonic, radiation tracer and infrared techniques as well as thermometric methods, radiation pyrometer method and acoustic emission methods. Examples are given on NDT acoustic inspection on pressure vessels and storage tanks and results are discussed.

12. Material Standards (Raaber, B. Wischin from TUV, Austria)

In general various types of materials are used as construction material for the equipment in a refinery depending on the type and the strength of stress to which it is exposed: for temperatures up to 400°C carbon and low alloy steel, for high temperatures chromium steel, austenitic steel, for high pressure in presence of hydrogen chromium steel, and others. The Austrian legislation on pressure vessels defines the standards under which quality systems certificates can be granted for certain products operating under pressure. In addition, inspection of these units must be done in the presence of TUV (Technical Inspection and Control Authority). Only with their certificate the tested unit can be put into operation.

13. Trouble Shooting (H. Miglitsch)

Trouble shooting and predictive maintenance are closely linked. Today's machinery, e.g., turbo-machinery is technically getting more and more sophisticated and better trouble shooting techniques have become essential. Some recommendations are given to avoid malfunctioning of turbo-compressors, turbines, reciprocating compressors and other rotating equipment, such as pumps, fans, gears units. For compressor and turbine units, permanent monitoring of the vibration is necessary since vibration is one of the most frequent causes of failure of such units.

14. Analytical Trouble Shooting (H. Huber)

Methods and techniques are presented for supporting decision making and prediction of critical situations. The four models of reasoning in daily routine work - namely to determine the reason for troubles, to choose the best measure, to recognize problems ahead of time, to split a complex situation into parts - can be optimized by rational techniques. Although the approach to decision making and problem solving as described is of general nature, its practical application to maintenance within a refinery will have an impact on the efficiency of such a refinery.

15. Recuperation of Flare Gas

Even at thorough, normal operation of refineries and petrochemical plants, combustible gases (flare gases and tail gases) are developed, which represent a considerable waste of energy. OMV has therefore developed an economic flare gas utilization process, whereby the flare gas is fed into the fuel gas system of the plant. Care must be taken to avoid air in the recuperation unit for well-known reasons. The operation of this plant is automatic to the greatest possible extent to keep the whole system economic. The plant presently installed at OMV has a nominal capacity of 5000 m^3/hour. The process has been patented.

16. Planning a Repair Shop (P. Kielhauser)

A detailed analysis shows that maintenance costs can be reduced by careful planning of repair shops for the refinery. The main questions to be answered are: What is the maintenance demand? How can this demand be met? Where should the repair shops be located? Will repair shops need extension? How to plan the internal organization? How to plan equipment storage? All planning steps have to undergo critical evaluation with a view to their impacts on economics.

17. Training of Maintenance Personnel (J. Schweng)

Maintenance work may be done by contractors or by own personnel. Most refineries follow a mixed system whereby services like cleaning, welding, etc. are done through contractor and long/short-term repair/ turnarounds by refinery personnel. Skilled personnel is usually provided through recruitment of specialists from other refineries or by on-the-job training of experienced workers from other industries. A very important source for skilled workers is established through an apprenticeship programme in Austria. Nearly 60,000 students start every year such an apprenticeship in various fields/trades, whereby the apprentice receives practical on-the-job training according to a well established and approved training schedule and theoretical training in a vocational school (dual system). After 3.5 years a certificate as a qualified worker is awarded. At ÖMV 60 new apprendiceships were started in 1983.

A large part of training of maintenance personnel is done during installation and start-up of new units when experienced workers from contractors, manufacturers, engineering companies work together with the own workshop personnel. This is the moment for acquiring know-how in trouble shooting and repair work.

New training methods such as audio-visual and video programmes are now available. In addition, interactive training systems and simulator systems can be applied which represent very powerful training techniques, especially for training in the operation and maintenance of highly sophisticated machinery and instrumentation.